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PATENT SPECIFICATION

Inventor: RUBEN OLOF PETERSON

736,253

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(Divided out of No. 736,217).

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COMPLETE SPECIFICATION

Improvements relating to the Cleaning, Removal of Scale, Conditioning and the like of Metal Surfaces

We, THE OSBORN MANFACTURING COMPANY, of 5401 Hamilton Avenue, Cleveland 14, Ohio United States of America, a corporation duly organised and existing under the laws of the State of Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relating to the conditioning of metal sheets, strip, rod and the like has more particular regard to means and methods for attaining such beneficiating effects as the removal of scale and other closely adherent coatings and small slivers, the rounding of the sharp edges of small pits and scratches, the reduction of differences in hardness and associated physical qualities of small adjacent surface areas and small adjacent subsurface component formations, the cleaning and polishing of the surface, and the reduction of surface tension on such articles by brushing action and by the conjoint action, on the surface being treated, of a brush and of auxiliary materials such as abrasive, peening pellets, or other hard granular material.

The addition of an abrasive to a brushing operation in order to clean the surface of a metal sheet or like article by an ordinary scouring operation is, of course, well known. Thus, floors have been long cleaned and polished in this manner. It has also been proposed to clean sheet metal plates by similarly supplying an abrasive, e.g. sand, to the surface of the sheet in advance of the application thereto of a rotary brush. However, such simple scouring treatment has not proved effective for the removal of closely adherent oxide coatings, such as heat-formed scale, from sheet or strip steel or rod, in order to prepare such metal for further reduction as by rolling or drawing or to prepare the surface of such metal for plating with another metal, such as tin or zinc, or to receive and retain a paint, lacquer, or enamel coating, without employing more costly, objectionable and less beneficial pickling, processes.

An aspect of the continuing problem presented includes the removal of small slivers and the sharp edges of pits and scratches which are not removed by prior methods and which when not removed become, upon subsequent rolling, drawing, or the like, the sources of miniature seams and the starting points of fractures when an article made from the metal sheet, strip or rod is subjected to stresses of manufacture and use. Also a phase of the problem involves the minimizing of differences in hardness and associated physical qualities of small adjacent surface areas and small adjacent subsurface component formations, which differences, when permitted to become exaggerated, reduce the facility with which the metal may be worked and reduce some of the desirable qualities of the articles made therefrom. Some commonly used methods and means, such as for example scale-breaking and subsequent pickling to remove the scale, exaggerate such differences and therefore have serious detrimental effects while achieving the main objective.

As indicated above, one object of the present invention is to combine brushing action with application of an abrasive material in such a manner as will effectually accomplish the removal of scale, small slivers, and other objectionable surface irregularities from metal sheets, strip, rod and similar articles. It has been discovered that if such abrasive material be forcibly discharged onto the surface of a sheet simultaneously with the application of a brush thereto, not only is the cleaning action greatly improved but the power required for brushing greatly reduced. It has further been discovered that where, as will be desirable, a rotary brush is employed, such brush itself may be utilized thus forcibly to discharge, by centrifugal action, the abrasive material onto the surface of the sheet without detracting

[Prio

from, but on the contrary greatly increasing, the efficiency of the brushing action proper. It has further been discovered that improved results are obtained by flexing the work and subjecting the convex surface so formed to the brushing action.

Furthermore, in such method we may utilize abrasive material either in dry granular form having various degrees of fineness or such abrasive may be carried by a suitable liquid vehicle. The invention further comprehends improved means of conducting the abrasive in either such form to the brush in such manner as to utilize the centrifugal action of the latter to forcibly discharge the abrasive onto the sheet. A further feature of the invention resides in the employment of an abrasive consisting substantially entirely of previously removed scale particles.

The accompanying drawings and the following description set forth in detail certain means of carrying out the invention, such disclosed means illustrating, however, but some of various ways in which the invention may be used.

In said accompanying drawings:—

Fig. 1 is a diagrammatic side elevational view of one form of apparatus constructed in accordance with the present invention and showing a metal strip in process of being acted upon thereby;

Fig. 2 is a central longitudinal section of one of the brushes, shown as being utilized in such apparatus, wherein the centrifugal action of the brush is utilized to discharge granular abrasive material onto the sheet being treated;

Fig. 2a shows a detail of Fig. 2 on larger scale;

Fig. 3 is a transverse section of such brush, the plane of the section being indicated by the line 3—3, Fig. 2; and

Fig. 4 is a diagrammatic side elevational view of a further form of apparatus constructed in accordance with our invention and showing a metal strip in process of being acted upon thereby.

Referring to the construction of apparatus illustrated in Fig. 1, such apparatus will be seen to comprise two rolls 1 and 2, about which the metal strip S is passed in such manner that each side of the strip will be respectively subjected to the action of rotating cylindrical brushes 3 and 4 which are disposed with their axes respectively parallel to the corresponding rolls (which may be disposed at desired angles to the longitudinal axis of the strip) and so spaced in relation thereto that the brushes will contact with the accurately flexed portions of the strip as it passes over and is supported by said rolls respectively. The rolls 1 and 2 of course are rotated so that their peripheries at their points of contact with the strip move in the same direction as the strip in passing over said rolls and the brushes 3 and 4 will be rotated in a direction opposite to that of the rolls, i.e. in the same direction as that in which the strip moves while in contact with the latter, or in a reverse direction, or alternately first in one direction and then in another for short periods of time. Certain brush materials work best when they are continually sharpened by alternately operating the brush first in one direction and then in the other. Also, the direction of operation of a brush determines which sides of pits or scratches and corresponding sharp edges of which will be most effectively rounded by a given brush. It is, therefore, desirable to employ several brushes and to have their respective directions of operation so adjusted and periodically alternated as to have their effective operational directions adjusted to several different related angles. The rolls and brushes will be power driven, either by direct motor drive or otherwise as found desirable or convenient, the brushes preferably being rotated rapidly, for example at approximately 3000 R.P.M. in the case of a 12 in. diameter brush, which will be approximately equal to an average of 9000 F.P.M. while the strip of course moves at a much lower speed, relative to the speed at which the contacting brush surfaces travel. Brushes larger than 12 inches in diameter will often be preferred.

For the purpose of feeding the strip to the rolls 1 and 2, as it is received from roller conveyor 5 it passes between relatively adjustable bending rolls 6, 7 and 8 which serve to arcuately bend the strip to a curve of somewhat greater diameter than that of roll 1. The strip then passes between guide rollers 9 and 10, which direct it into substantially tangential relationship to the surface of the roll directly opposite brush 3. Beyond the roll 1 the strip passes between rollers 11 and 12, which are disposed in a relationship to said roll complementary to that of rollers 9 and 10.

As a result of the disposition of the two pairs of guide rollers the area of contact of the strip S on its concave side with the roll 1 is limited substantially to that of the area of contact of its convex side with the opposed rotating brush 3. The brush will be set no more tightly against the strip S than necessary to obtain the desired effect, since the friction losses between the brush and the strip increase more rapidly than the square of the pressure, and the power consumption is of course a factor of importance. Over-brushing of the metal surface furthermore may have detrimental effects in forming characteristic irregularities and removing and displacing too much metal.

Directly below the point of tangency of roll 1 and brush 3 is an exhaust collector 13 adapted to receive the particles of scale removed from the strip by the action of brush 3 as well as additional granular abrasive material which, as will presently be described, will be supplied to the brush for use in the treatment of the

strip. A suction fan 14, connected with collector 13, serves to convey the abrasive including such scale along a duct 15 in which is interposed a screen 16 whereby the larger particles are caught and collected in a trap 17. The remaining, finer particles of scale are delivered by duct 15 to a hopper 18 located conveniently adjacent brush 3 from which such abrasive particles may be supplied to the brush in the manner presently to be described.

Returning to the progress of the strip S, after leaving guide rollers 11 and 12 it then continues between bending rolls 20, 21 and 22, whereby it is arcuately bent in the opposite direction from that given it by the first-mentioned set of bending rolls and caused to tangentially engage roll 2 where its other side, now convex, is subjected to the action of brush 4. Disposed on opposite sides of roll 2 are complementary pairs of guide rollers 23, 24 and 25, 26 which, like the previously mentioned pairs of guide rollers, serve to limit the area of contact which the strip S has with roll 2. Finally, the strip is received between straightening rolls 27, 28 and 29 which straighten the strip and enable it to continue in its original direction along the roller conveyor 30. Associated with brush 4 is a collector 31 and suction fan 32, which are connected with a suitable hopper associated with brush 4 through a duct (not shown), in the same manner as in the case of the collector and hopper associated with brush 3. If brushes 3 and 4 are adapted to be periodically reversed in operation, as preferred, then of course similar collectors should also be provided at the other sides of the brushes.

As indicated, the rotary brushes 3 and 4 which are disposed to operate on the convexly flexed surface of the strip as it moves through the apparatus will in effect be duplicates of each other, being designed to perform the same operation on opposite sides of such strip; furthermore, each such brush is so constructed as to adapt the same to forcefully project abrasive material onto such convexly flexed surface of the strip. A preferred construction of brush designed to operate in the manner just referred to is shown in Figs. 2, 2*a* and 3, which will now be described. As there shown, the body of the brush comprises two oppositely disposed hub members 35 and 36 respectively provided with bearing sleeves 35*a* and 36*a* whereby said members may be rotatably supported in suitable journals. Fitted to said hub members is a cylindrical shell 37 that is provided with a suitable number of properly spaced perforations 38 through the portion thereof lying between the hub members to permit the discharge outwardly through such shell of abrasive material supplied to the interior thereof. Mounted in turn on shell 37 is a body 39 of radially extending stranded brush material. This material may consist of crimped wire of varying degrees of fineness, or any of the other materials usually employed in brushing operations of the character involved, and may be secured to the shell in any approved manner. As illustrated, such brush material is disposed in the form of doubled layers held by a retaining wire or ring 40 in a channelform base 41 which may be either in the form of an annulus or wound helically about the shell. Retaining rings 42 held in place by means of lock rings 43 threaded on the respective ends of the shell press against the corresponding sides of the assembled body of brush material and serve both to secure the latter to the shell and compact the same to the desired degree.

Where the brush material is held in a channelform base 41, the sides of the latter, as shown in Fig. 2*a*, are formed with alternate depressed areas and intermediate lands so that radial passages will be left between adjacent bases (or sections of the base where helically wound on the shell) and the number and disposition of the perforations 38 in the shell 37 will be such that a substantial portion, if not all, of the passages thus provided will coincide in location with such perforations so that abrasive supplied in the manner previously referred to may pass through the latter and such passages and thence outwardly in between the stranded brush material. Such relatively free flow of abrasive is further facilitated by rounding the lower corners of the channelform bases so that circumferential passages are provided between adjacent bases which will further ensure connections between the perforations in the shell and such radial passages.

The specific construction just described, whereby provision is made for the flow of abrasive from within the shell 37 into the body of stranded brush material, forms the subject matter of our Patent No. 657,749, and it will be understood that where different methods of attaching the stranded brush material to the brush body are employed, other means for providing for such flow may require to be used. In other words, the illustrated construction is to be considered merely as constituting one form of brush body wherein provision is made for such flow of abrasive from the interior thereof radially outwardly into the stranded brush material.

Further referring to Figs. 2 and 3, it will be seen that a tubular shaft 45 extends axially through the body of the brush, the ends of such shaft projecting beyond the respective hubs 35 and 36. The intermediate portion of the shaft, i.e. that lying between such hubs within shell 37, is provided with a longitudinally aligned series of apertures 46 through which abrasive or other flowable material may be introduced into the hollow interior of the brush body. Such material may be supplied from any suitable source to the tube through either end thereof, the right-hand end being shown as selected for the purpose in Fig. 2. A solid rod 47 inserted in the other end of

the tubular shaft serves to close off such end and being reciprocable said rod may be utilized for the further purposes of cleaning out the interior of the shaft should it, or the openings 46 therein, become clogged.

Tube 45 is not directly in contact with the openings in the hubs 35 and 36, but the portion thereof lying within hub 35 is surrounded by a second tubular shaft, or rather sleeve, 48 which serves as a close fitting bushing within which such shaft may be angularly adjusted, i.e. rotated about its axis so as correspondingly to vary the angular position of the series of perforations 46 in relation to the axis of the shaft. The portion of the shaft 45 which lies within hub 36 is similarly surrounded by a closely fitting tubular shaft 49 and said shaft 49 is in turn surrounded by a second tubular shaft or sleeve 50, the function of which is the same as that of sleeve 48 except that, as indicated, said shaft 49 is interposed between it and the innermost tubular shaft 45. Said shaft 49 projects into the hollow interior of the brush body and desirably includes an axially spaced extension in the form of a separate ring 51 that lies adjacent the inner face of hub 35, and fixedly attached to these portions of said shaft 49 is a radially projecting wiper 52. While the latter may take on various forms, it will desirably consist, as best shown in Fig. 3, of a straight channelform base 53, similar to the base employed to hold the brush material comprised in brush body 39, and a doubled layer of stranded brush material which is secured in such base just as the previously mentioned brush material is secured in the channel bases 41. The wiper thus constructed extends substantially across the space within shell 37 lying between the two hubs 35 and 36 and is of such radial extent that its outer edge, which, where the blade is formed of stranded brush material, will consist of the ends of such strands, will frictionally engage with the inner face of said shell.

Shaft 49 is normally held against rotation by suitable means and as a result rotation of the inner face of the shell 37 about such wiper serves to clear the perforations 38 in such shell should they become clogged while the brush is in use. However, when desired, tubular shaft 49 which carries the wiper 52 may be rotated, or rather adjusted angularly, about the axis of said shaft so as to correspondingly vary the angular position of the wiper within said shell. Any suitable means may be provided for thus rotatably adjusting said shaft 49 and for retaining the same against rotation as desired, e.g. a worm gear 49*a* attached to the projecting outer end of the shaft and a worm 49*b* engaging said gear.

In order to facilitate insertion and removal of shaft 49 with the wiper thus carried thereby, a radial slot 54 is cut in hub 36, such slot being of proper width to permit the ready passage therethrough of the blade, however constructed. When the blade is in its operative position, as shown in Figs. 2 and 3, such passage will be closed by a plug 55 that is held in place by means of a flange on the bushing 36*a*.

While the wiper assembly must necessarily be inserted before the brush is placed in its bearings, thereafter the angular adjustment of the wiper can be made without disturbing the brush mounting. Likewise, the feeder tube 45 can be inserted and removed, as can also the reciprocable clean-out shaft or plug 47, all without disturbing the brush set-up.

The manner in which a brush constructed as just described is utilized in a brushing operation such as that illustrated in Fig. 1 will now be set forth. Assuming the open end of feed tube 45 to be connected with a suitable supply of granular abrasive, or other material such as more fully set forth later herein, which may be carried by a stream of air or other suitable vehicle moving at proper velocity, such abrasive or the like will be carried into the hollow interior of the brush body and there be subjected to the centrifugal force occasioned by the high rate of rotation of such body when the brush is in operation. The effect will be to cause the abrasive to flow through the perforations 38 in shell 37 and thence to discharge the same at an accelerated rate of movement through the stranded body of brush material. The direction of such discharge can be effectively controlled by rotating the feed tube so as to vary the angular direction of the openings 46 therein, through which such abrasive is supplied to the hollow interior of the brush. Thus, for example, as such material is discharged from the stranded brush body, it can be directed onto the surface of the sheet being brushed along the line of contact of the brush therewith, or in advance of such line, as de- Such direction of discharge may be further controlled by utilizing the wiper 52 as a deflector, to which purpose it is equally well adapted. In other words, by proper angular adjustment of the feed tube and of such wiper thus serving as a deflector, the angle at which the major portion of the abrasive will be discharged from the brush can be fairly closely controlled.

It is not necessary of course that all of the particles of abrasive should fall within a defined area on the strip, but merely that the major portion thereof should do so. In order to catch such particles as may be thrown beyond the desired area, any suitable form of enclosure or guard may be employed. It will be further understood that while reference has been made in the foregoing description of the operation of our improved brush to the use of a granular abrasive conveyed by a stream of air, other media, including a suitable liquid, may be employed, such liquid carrying the abrasive being discharged in the same manner. Moreover, for certain purposes the material supplied to the brush for the purpose of thus being

centrifugally discharged therefrom may consist wholly of a liquid medium capable of having a beneficiating effect on the surface of the strip as it is being brushed.

Referring now more particularly to Fig. 4, the apparatus in the form therein disclosed comprises two rolls 92 and 93 about which the metal strip 94 is adapted to pass in such manner that each side of the strip will be subjected to the action of one of the brushes 95 and 96. These brushes will generally be rotating at speeds in the vicinity of 9000 F.P.M. and their directions of rotation will desirably be periodically reversed, the rate of travel of the strip ordinarily being sufficiently slow that no consideration needs be given thereto in this connection. The strip of course is moving at a much lower relative speed.

The end of the strip approaches the machine sliding along conveyor 97 until it strikes large roll 92 whereupon the end of the strip is deflected and received between the surface of such roll and a small auxiliary roll 98 carried by a spring-backed mount 99 provided with an adjustable stop 100 operative to limit maximum movement of roll 98. Rotation of roll 92, which is driven from any suitable power source, then operates to pull the strip into the nip of the two rolls and the strip is driven forward against roll 101 which is mounted in a manner similar to roll 98 and very close to the latter (detailed mounting means not shown for purposes of clarity). The strip is then driven onward between rolls 92 and 101 and becomes arcuately bent through the interaction of rolls 92, 98 and 101 to a radius substantially conforming to the surface of roll 92. The strip next passes under a spring loaded shoe 102 carrying one or more rollers 103 similarly operable to bear upon the strip. The smooth curved surface of shoe 102 adjacent roll 92 is sufficiently removed from roll 92 to afford ample clearance for passage of the strip but serves to deflect such strip should the latter fail closely to conform to the surface of roll 92. Spring 104 is effective to cause rollers 103 to bear on the strip with considerable pressure in order to maintain the latter in tight engagement with roll 92 as it passes beneath brush 95. A second spring loaded shoe 105 provided with similar rollers 106 co-operates in maintaining the strip in close engagement with roll 92.

The strip then passes over pulley roller 107 and follows conveyor 109 to roll 93 where it passes between roll 93 and rolls 98^1, 101^1, 103^1, and 106^1, these rolls corresponding in mounting and function to the similar rolls above described. Deflector 110 separates the strip from roll 93 whereupon it passes between rolls 111, 112, and 113 which have a straightening effect upon the strip which now resumes its course in its original direction along conveyor 114. Roll 93 may be driven similarly to roll 92, either through a train of gears or alternatively by means of a separate electric motor, for example, which may be caused to turn roll 93 at a slightly greater speed than roll 92 to aid in keeping the strip tight.

Directly below the point of contact of roll 92 and brush 95 is an exhaust collector 115 adapted to receive the particles such as scale discharged by the action of the brush. An appropriate blower 116 forces the scale along duct 117 to screen 118 where the larger particles are caught and collected in trap 119. The finer particles of scale are carried to hopper 120 from the bottom of which they are fed or preferably forced to the outer periphery of the rapidly rotating brush 95. By means of this arrangement the abrasive that is delivered to the brush is impelled against the convex surface of the strip by the brush in the general direction of engagement between such brush and strip, i.e. in a direction generally tangential to the curvature of the strip. The abrasive particles may be supplied to the work either by a controlled gravity feed of any usual type or by an air blast of familiar construction, and these particles may be thus discharged against the surface of the strip being treated, with only a portion being delivered to the periphery of the brush prior to engagement with such strip. A similar system, the parts of which are identified by like numerals, is provided for brush 96. Since the details of the system form no part of the present invention, it has been considered unnecessary to illustrate other than in diagrammatic fashion the specific construction of feeding means, whether gravity or air blast, thus associated with hoppers 120.

While the improved method and apparatus for surface beneficiating metal sheets and the like has been described with special reference to the removal of scale and like closely adherent coatings, no limitation to such particular use is to be implied. Thus, by employing other forms of hard granular material instead of a conventional abrasive, e.g. peening pellets of properly selected size, such method and apparatus may be equally well employed in the peening treatment of sheets and like metal articles.

In peening practice as at present carried out, while the impact of the pellets or "shot" has the desired effect of relieving surface tensions and otherwise beneficiating the surface of the article being treated, there is at the same time produced a disadvantageous effect arising from the presence of the crushed cementite and other constituents of steel. Where the broken fragments of such materials, which are relatively hard, remain on the surface, not only is the peening action interfered with but the surface itself may be permanently marred. However, by combining with the impact action of peening pellets a brushing action, these objectionable products are immediately removed and a much better surface condition obtained.

Where peening pellets are employed, they

will of course be fed onto the workpiece by means of the brush so as to be projected therefrom by centrifugal action of the latter in the same manner as the granular abrasive material previously referred to. Furthermore, as has hereinbefore been pointed out, the improved construction of brush and the method involved in its use may be found quite advantageous where instead of thus feeding discrete hard particles through the brush, other kinds of beneficiating materials, e.g. in liquid form, are thus applied to the surface of the article being treated, without carrying any granular abrasive or other additional material.

While the means and method hereinbefore described for centrifugally discharging abrasive or other beneficiating material onto the surface being treated, viz. by feeding the same into the interior of a brush rotating at high speed, thence to pass radially outwardly through the stranded brush material, are considered preferable, it has been found that a like effect may be obtained by supplying such material at the proper point or points on the surface of such a brush. An appropriate shield or baffle will ordinarily be employed therewith.

The term "surface beneficiation" as employed herein is to be understood as comprehending any of the several forms of treatment mentioned, e.g. cleaning, polishing, scale removal and relieving surface tension. In addition to the latter, the application of brushing action has been found effective to reduce stress concentration characteristics in the surface of the treated article, where the brushing action is applied in at least four angularly related directions, since by brushing in this manner all of the upstanding edges of so-called "craters" will be smoothed down, or substantially removed.

The surface irregularities of metal sheets, such as minute craters, have their marginal edges effectively smoothed and rounded by the ends of the brush bristles passing in at least three angularly related directions thereacross. This brushing action, by blending such sharp margins serves to relieve stress concentrations at such points on the metal surface and by the same action reduces susceptibility to corrosion as well as performing the function of cleaning the surface. The ends of the brush bristles have a definite peening, wiping and polishing action which it has been found, however, must be in at least three angularly related directions to be effetcive on the entire circumference of each minute surface irregularity. Thus, small slivers extending from the surface of the metal article are likewise most completely removed when thus brushed.

The desired abrasive brushing action may be obtained by the employment of relatively hard wire brush bristle material, for example, or by supplying suitable abrasive for application by brushes utilizing less hard bristle material. While a slight peening action is desirable, as by impelling such abrasive by action of the brushes, this will be considerably less than that obtained in conventional shot blast or equivalent procedures employed in the past in an attempt to remove scale from metal strip. The extreme peening action of prior art abrasive blasting procedures has tended both to embed particles of abrasive in the metal surface and also to cause excessive work-hardening of the metal surface having a deterimental effect on subsequent reduction as by rolling and manufacturing operations.

After treatment in accordance with the invention, the metal surface will in many cases be found to be of much more uniform Knoop hardness than when the scale has been removed by conventional pickling procedures. Furthermore, the scale is removed in a dry state and may be salvaged for employment as an abrasive or for reduction as with hydrogen for employment in powder metallurgy, or the making of pigments and the like. The brushing, moreover, may relieve surface strains and regularize the surface, thereby eliminating "hard spots" so that subsequent reduction by rolling is facilitated. It may be found, in fact, that considerably greater reduction than normally can thereafter be achieved before annealing becomes necessary. Similar brushes may be disposed to engage the edges of the strip not only removing scale therefrom but acting to prevent formation of incipient cracks during subsequent rolling which have in the past necessitated trimming and scrapping of edge portions of the strip.

What we claim is:—

1. A method of beneficiating a metal surface which comprises flexing such surface convexly, brushing such flexed convex surface and simultaneously subjecting the surface to the action of a fluid surface beneficiating material forcibly projected against the portion of the surface being brushed.

2. A method of beneficiating a metal surface, which comprises flexing the surface convexly, brushing such flexed convex surface and simultaneously forcibly projecting a hard granular material to the same portion of the surface thus being brushed.

3. A method according to Claim 2, wherein the hard granular material consists substantially entirely of previously removed scale particles.

4. A method according to Claim 2, wherein sheet, which comprises flexing the sheet, brush- the convex face of the latter, collecting the particles of scale removed from such sheet by such brushing operation, and forcibly projecting such particles against the portion of the face of the sheet being brushed while subjecting the same to the brushing step.

5. A method according to any one of Claims 1 to 4, wherein said brushing is effected by a rotary brush whose axis extends parallel to the line of flexing of the surface engaged by the

brush, the brushing action taking place in a direction normal to such line.

6. A method according to any one of Claims 2 to 5, wherein the hard granular material is forcefully projected onto the convexly flexed surface.

7. A method of removing scale from a metal sheet which comprises progressively flexing such sheet convexly to raise the edges of the scale particles; brushing such convexly flexed portion of the sheet by a rotary brush whose axis extends parallel to the line of flexing engaged by the brush, such brushing action taking place in a direction normal to such line; and simultaneously forcefully projecting hard granular material onto the portion of the face of the sheet being brushed in a direction generally tangential to the curvature thereof.

8. A method according to any one of Claims 2 to 7, wherein the hard granular material is supplied to the brush so as to be projected thereby onto the convexly flexed portion of the metal surface.

9. A method according to Claim 8, wherein said material is projected by means of a brush substantially as herein described with reference to Figs. 2, 2*a*, and 3 of the accompanying drawings.

10. A method of removing scale from a metal sheet which comprises progressively flexing such sheet convexly to raise the edges of the scale particles, brushing such convexly flexed surface and forcefully projecting abrasive material onto the portion of the sheet being brushed in a direction generally tangential to the curvature thereof.

11. A method of beneficiating a metal surface as herein described.

12. Apparatus having means adapted and arranged for carrying out the steps of a method according to any one of the preceding claims.

13. The forms of apparatus herein described with reference to the accompanying drawings.

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Fig.1.

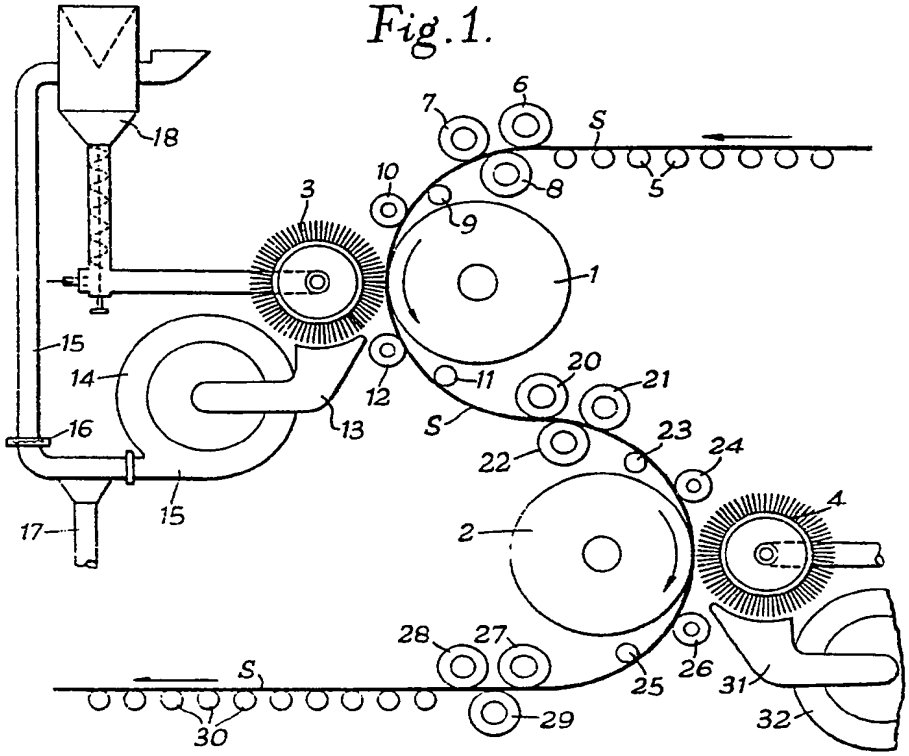
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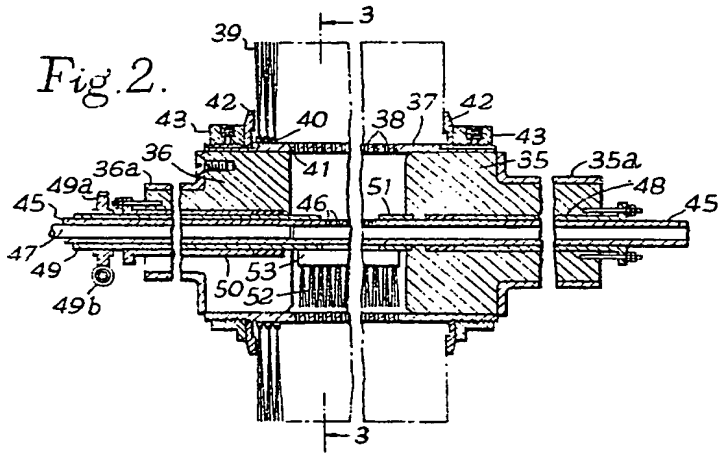
Fig.2.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736,253 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig.2a.

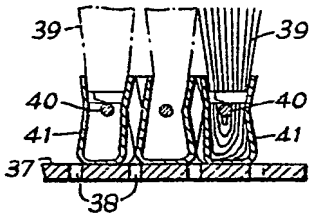


Fig.3.

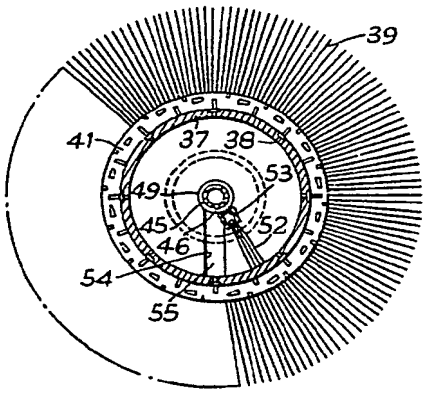
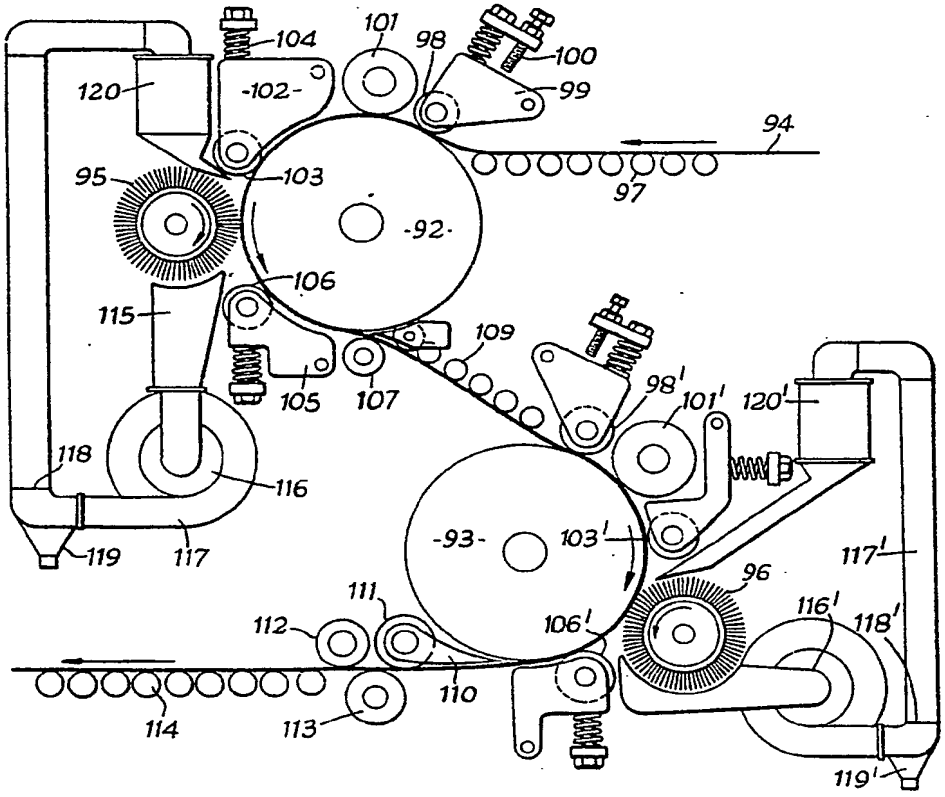


Fig.4.



736,253 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig. 1.

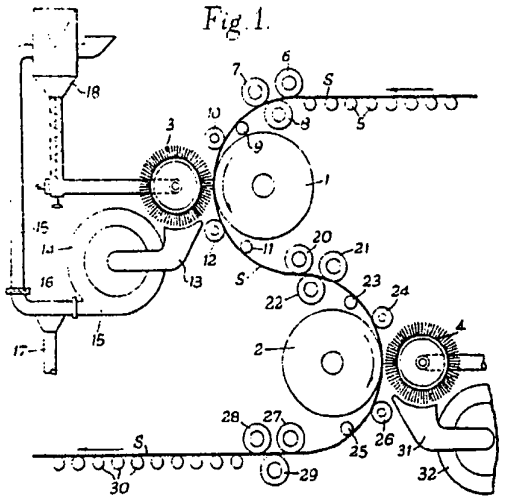


Fig. 2.

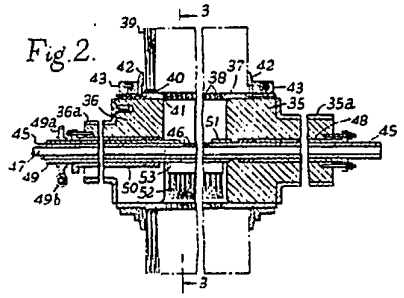


Fig. 2a.

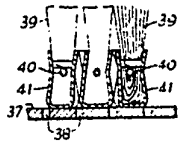


Fig. 3.

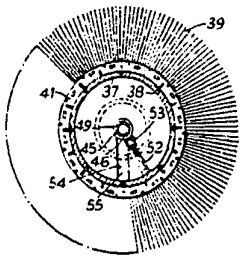


Fig. 4.

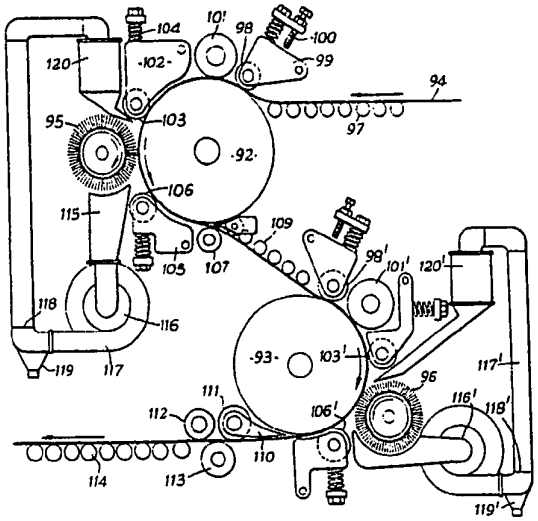


Fig. 1.

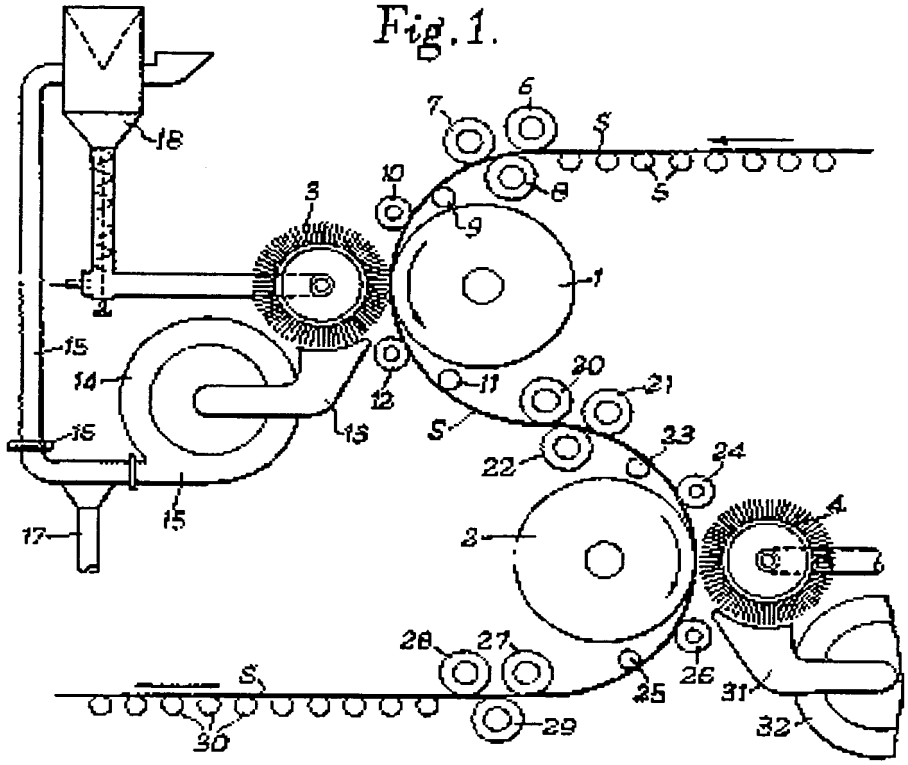
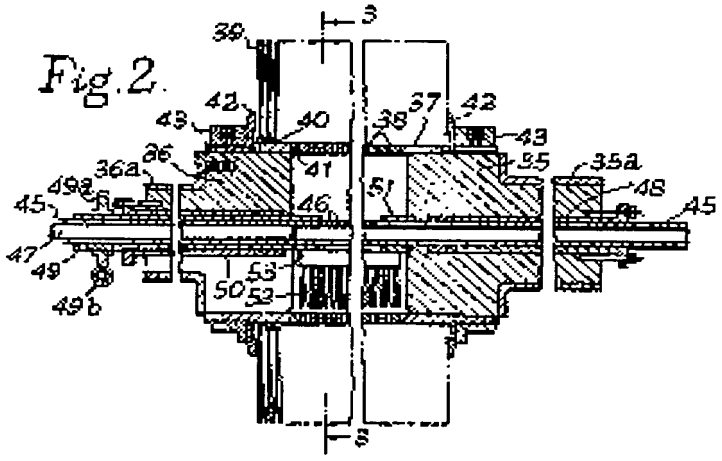


Fig. 2.



736,253 COMPLETE SPECIFICATION

2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 1 & 2

Fig.2a.

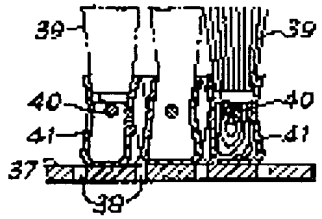


Fig.3.

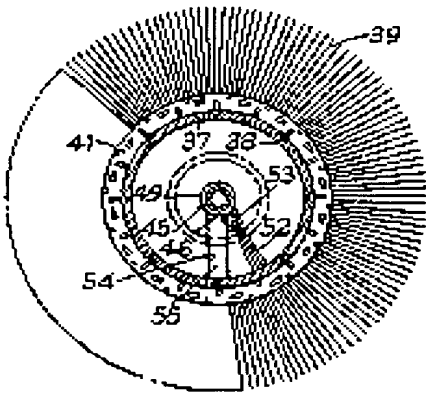
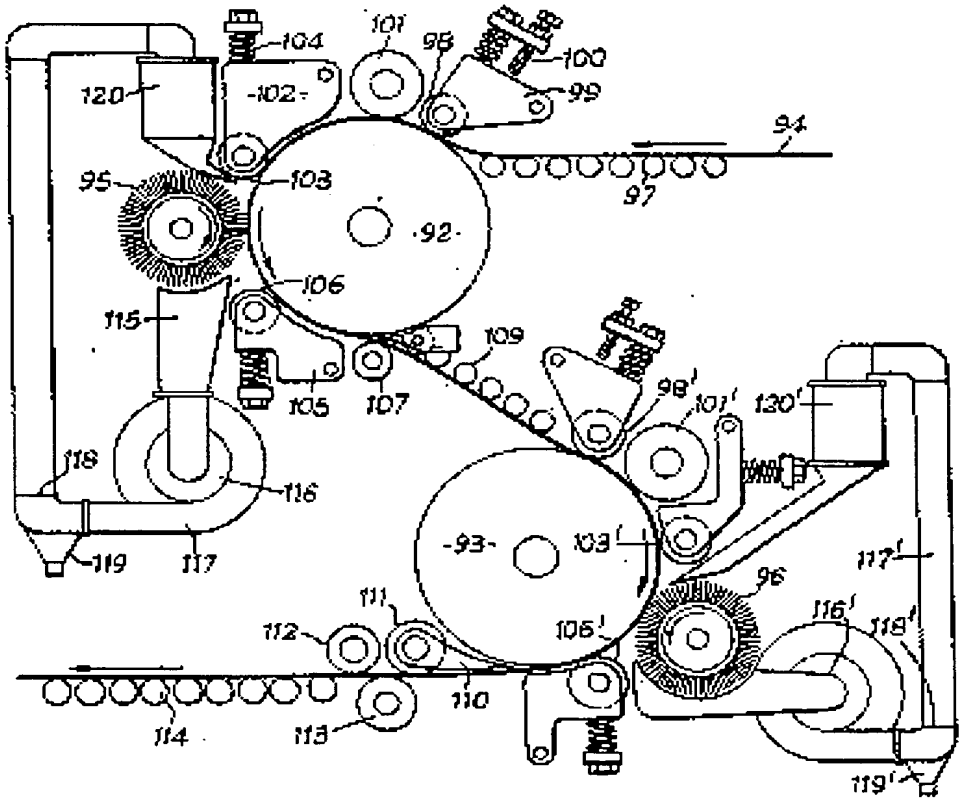


Fig.4.



736,253 COMPLETE SPECIFICATION
2 SHEETS

Fig. 1.

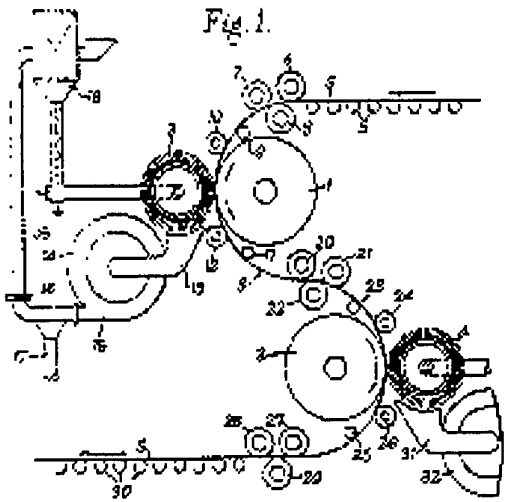


Fig. 2.

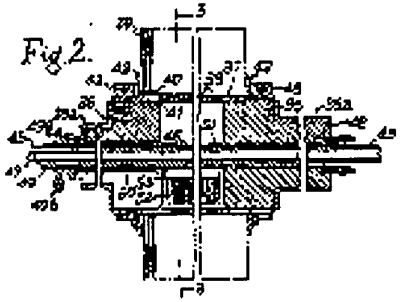


Fig. 2a.

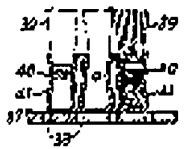


Fig. 3.

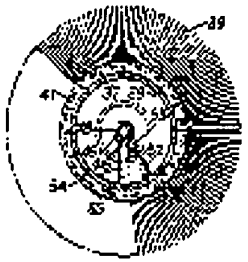


Fig. 4.